Surface Erosional Processes and Management Practices on the Clearwater National Forest

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Introduction

This paper discusses surface erosion and the management practices that affect these processes on the Clearwater National Forest. Surface erosional processes are first natural and occur in unmanaged and managed watersheds. Management activities, including timber harvest, prescribed fire, and road construction and maintenance can accelerate surface erosion. The task before the Forest Supervisor or district ranger is to manage the watershed and occasionally extract commodity resources while avoiding or minimizing accelerated erosion.

Surface and mass erosion is not inherently bad. These natural processes are the source of, not only sediment, but also spawning gravel and cobble in streams. Without erosional processes in balance with the hydrologic cycle, including precipitation, evapotranspiration, and runoff, stream channels would scour to bedrock and fisheries habitat would be absent from the Forest's streams. Erosional processes are only "bad" when they are accelerated to the point where they are out of balance with the hydrologic processes occurring within the watershed. When that happens, aggradation in the channel can accelerate stream bank erosion and embed spawning gravel and cobble. The Forest's watershed managers seek to avoid these impacts.

Surface Erosion

Surface erosion is defined as the detachment and transport of soil particles by running water, waves, currents, moving ice, wind, or gravity (Armantrout, 1998). For the purpose of this paper, the Clearwater national Forest includes, as part of surface erosion, splash, sheet, rill, and gully erosion. One of the main objectives of management practices on the Clearwater National Forest is to control or eliminate accelerated surface erosion to the extent possible, while allowing resource management to proceed. These management practices, first includes avoidance, then preventative measures, and last erosion control measures.

Avoidance is the first and most effective way the Clearwater National Forest controls surface erosion. Decisions are regularly made during the NEPA process to eliminate projects, or portions thereof that would cause accelerated erosion and deliver sediment to streams. These often include practices such as the construction of lower or mid-slope roads on unstable landtypes, tractor logging with excavated skid trails on soils with erosive parent materials, and logging or prescribed fires in Riparian Habitat Conservation Areas (RHCA's). By avoiding such practices, to the extent possible, erosion and resultant sediment delivery to streams is greatly reduced or eliminated. Practices that generally are carried forward that produce little if any sediment delivery to streams include such things as logging from existing roads, construction of ridge-top or near ridge-top roads that do not cross streams, logging of steep terrain with cable or helicopter logging systems, tractor logging from existing skid trails or from non-excavated skid trails on gentle terrain, and low intensity prescribed fires.

Erosion control measures are after the fact and are often used to reduce erosion from existing facilities that were constructed years ago. Two methods the Clearwater uses to reduce existing erosion and sediment delivery to streams are road maintenance and road obliteration. Annually, the Clearwater National Forest maintains approximately 500 miles of its 4,500 miles of system roads and completes approximately 50 miles of road obliteration. Road obliteration began on the Clearwater in 1992. To date, 329.1 miles of roads have been obliterated; 77.5 miles have been abandoned; and 38.2 miles have been placed in long-term intermittent use.[1] Often, these road maintenance and road obliteration projects are on the most erosive landtypes where the potential for sediment delivery is high. Road maintenance is concentrated on roads that have heavy use and are located adjacent to streams where the risk of sedimentation is high. Road obliteration is concentrated on Idaho jammer and other formally abandoned roads where the risk of mass wasting and surface erosion remains high and where hydrologic function and integrity has been disrupted.

Best Management Practices (BMP's) are the main *Preventative measures* used on the Clearwater National Forest to control surface erosion and sediment delivery to streams during forest practices, including timber harvest, road construction, maintenance, and site preparation. Design and application of BMP's has been the primary means of controlling nonpoint sources of pollution on National Forest System administered lands (Harper, 1987 and Potyondy, 1992). BMP's are defined as:

> "A practice or combination of practices, that are determined by a state, or designated area-wide planning agency, after problem assessment, examination of alternative practices, and appropriate public participation, to be the most effective, practicable (including technological, economic and institution considerations) means of preventing or reducing the amount of pollution generated by Nonpoint sources to a level compatible with water quality goals." (Federal Register, 1975).

The approved BMP's for forest practices on the Clearwater National Forest are the Idaho Forest Practices Act (Idaho Department of Lands, 2000) and the Forest Service, Region 1 Soil and Water Conservation Practices Handbook (USDA Forest Service, 1988). These BMP's are implemented during timber sales through the timber sale contract standard

[1] *Obliterated* roads have had unstable fill slopes removed, stream crossings have been re-contoured, and exposed earth is seeded and mulched. Depending on the site-specific needs, the treatment can include out-sloping or partial or complete re-contouring. *Abandon* roads have no future need for road maintenance. They are revegetated, stable, and do not have culverts. Roads in *long-term intermittent* use have had all culverts removed, stream crossings have been re-contoured, and fill slopes are left in a stable condition. The road prism is retained for future use.

provisions and during road construction projects through road contract provisions. Timber sale administrators and contracting officers are trained in the implementation of BMP's and assure they are properly applied. The Idaho Forest Practices Act (FPA) includes BMP's applied during timber sale planning and implementation that protect soils, locate landings and skid trails, control drainage, treat waste materials, and provide for the protection of streams. The FPA also includes BMP's that are applied during road construction, reconstruction, and maintenance. The Soil and Water Conservation Practices Handbook includes BMP's that are implemented during watershed management, recreation development, vegetative manipulation, timber sales, road and trail construction and maintenance, minerals development and extraction, range management, and fire suppression and fuels management projects. BMP's are designed to be site-specific to fit the practice to conditions found within the watershed.

To assure proper BMP implementation and effectiveness, the Clearwater National Forest conducts an annual BMP audit of the Forest Practices Act. These audits were conducted from 1990 through 1994 (USDA Forest Service, 1994) and again in 1996 through 2000 (USDA Forest Service, 1997) (USDA Forest Service, 1998) (USDA Forest Service, 1999) (USDA Forest Service, 2000). The results of the audits are shown in Table 1.

Table 1: Idaho Forest Practices Act Internal Audit 1990-1994, 1996-2000

Year	Number of BMP Checks	BMP's Implemented	% Implemented	BMP's Effective	% Effective
1990-1994	2,074	2,020	97.4	2,015	97.2
1996	298	294	98.7	291	97.7
1997	81	80	98.8	80	98.8
1998	343	341	99.4	341	99.4
1999	316	316	100.0	314	99.4
2000	232	230	99.1	230	99.1
10 Year Total	**3,344**	**3,281**	**98.1%**	**3,271**	**97.8%**

The information from the audits is provided through the Forest Supervisors and district rangers, to sale administrators and contracting officers where the results and recommendations are applied on the ground. When implementation or effectiveness problems are identified, recommendations are made to improve the site-specific practices. This "feedback loop" has worked as can be seen in Table 1. BMP effectiveness through 1996 was averaging approximately 97 percent. More recent BMP audits suggest that the effectiveness rate is now 99 percent. The results of the audits indicate that sediment and solar radiation does not reach streams as a result of timber harvesting and road construction in 97.8 percent of the practices applied. The audits have also been open to other individuals and agencies and their feedback has been invited. Over the years, numerous Forest Service employees have attended the field reviews, as well as individuals representing the Idaho Departments of Environmental Quality, Lands, and Fish and Game, and consultants from Western Watershed Analysts.

The BMP audits are an ocular survey of timber harvest units, prescribed burning, and roads. The units and roads are field checked to determine if the BMP's are properly implemented and if sediment or other pollutants are reaching streams. An ocular observation is also made to determine if sufficient shade and large organic debris is retained along Class I and Class II streams.

The first year the audits were conducted (1990), the Clearwater National Forest used a random approach to select the harvest units. During the field reviews it was discovered that many of the units were located on or near ridge tops where there was no potential for sediment to be delivered to streams. The State of Idaho also used somewhat of a random selection approach in the 2000 DEQ audit of the FPA and had some similar results (Hoeschler, 2000). After 1990, the Forest's selection process was modified to choose units that had adjacent or interior Class I or Class II streams. Sampling was skewed towards units and roads with higher potential for risk. District hydrologists and biologists have selected the units based on their knowledge of the ground and the risks involved. The audits have also been selected to include a variety of landforms and geologic parent materials. Timber sale units and roads have been audited on floodplains, river terraces, low relief rolling hills, mountain slopelands, glacial trough walls, glacial trough bottoms, mass wasted slopes, and non-dissected and dissected stream breaklands landtypes. Geologic parent materials present in the audits have included alluvial depositions, Idaho Batholith granites and gneisses, glacial deposited material, Belt series quartzites, Revett quartzites, basalt, and micaceous schists and associated Border Zone material (Wilson and others, 1983). The audits have occurred throughout the Forest, in the Palouse River, Lochsa River, Middle Fork Clearwater River, Lolo Creek, Orofino Creek, Potlatch River, Upper North Fork of the Clearwater River, and Lower North Fork of the Clearwater River watersheds.

Similar results have been obtained on the Nez Perce National Forest where audits of the Idaho Forest Practices Act go back to 1988. Their implementation rates have averaged between 95 and 100 percent for these years (Gerhardt, 2000). Idaho DEQ has also conducted audits of the Forest Practices Act statewide. In their 1996 FPA Audit, DEQ concluded that "the rates of forest practices rule implementation increased across all land ownership categories when the 1996 rate was compared to the 1988 and 1992 rates… When averaged statewide, the rate of rule implementation increased from 93 percent to 97 percent." Similar results were obtained for BMP effectiveness. "We found that, when properly applied and maintained, the management practices described in the Idaho forest practices rules are effective 99 percent of the time." (Idaho Division of Environmental Quality, 1997). DEQ completed its 2000 audit of the Forest Practices Act this summer. Five of the timber sales they audited were located on the Clearwater National Forest.[2] Preliminary findings indicated similar implementation results, however, data has not been sufficiently analyzed to determine effectiveness rates (Hoeschler, 2000).

Surface erosion is often categorized in the literature as *channelized* and *non-channelized* sediment (Trimble and Starz, 1957 and Swift, 1986). In recent years, appellants and litigants of Clearwater National Forest timber sales have criticized the Forest, stating, "Stream buffers are not effective in preventing channelized sediment." In the literature,

[2] Prospect Peak Timber Sale (July 18, 2000); Cougar-Ipsoot Timber Sale (July 18, 2000); Nat Brown Timber Sale (July 19, 2000); 5546 Salvage Sale (August 3, 2000); and Cedar-Chamook Salvage Sale (August 3, 2000).

the term “channelized sediment” is exclusively related to sediment derived from roads. Channelized sediment originates in road ditches and is delivered to ephemeral draws through relief culverts or delivered directly to streams from the road ditch. The travel distance of sediment that is channelized is obviously much greater than sediment that is non-channelized (sheet or overland erosion), such as from road fill slopes, harvest units, or broadcast burning (Belt and others, 1992). Burroughs and King (1989), in a Horse Creek study found that the maximum transport distance of sediment below relief culverts was 639 feet. Wasniewski (1994), in a study of five different roads within the South Fork of the Clearwater River watershed found sediment moving a maximum of 266 feet below relief culverts on newly constructed roads in granitic parent materials and 211 feet below relief culverts on newly constructed roads in gneiss/schist parent materials. In a study in Silver Creek, a granitic watershed without Mazama ash cap soils in Central Idaho, Ketcheson and Megahan (1996) found that channelized sediment from a road moved a maximum of 899 feet.

Buffer strips are vegetative bands along streams that are established to filter sediment and nutrients from upland watersheds; to enhance bank stability; to provide shade, shelter, and food for wildlife and for fish and other aquatic organisms; and to create visually diversified landscapes (DeBano et al., 1998). Maintaining buffer strips is an effective way of decreasing the amount of sediment from upland watersheds and preventing their deposition into streams (Neary et al., 1993). Burroughs and King (1989) found that sediment from fill slopes (non-channelized sediment) moved a maximum of 125 feet in the Horse Creek study. After an extensive review of similar literature, Belt and others (1992) concluded that, “filter strips on the order of 200-300 feet are generally effective in controlling sediment that is not channelized.” Quigley and others (1997), also after an exhaustive review of the literature, concluded that, “91 meter (300-foot) filter strips are generally effective in controlling sediment that is not channelized.” Belt and O’Laughlin (1994) state that the “key factors controlling sediment movement within buffer strips are the infiltration rate, slope, and density of obstructions… Research suggests that to control sediment, buffer strips should be wider where infiltration rates are low or slopes within the riparian zone are steep. Buffers are effective in controlling overland sediment flows, which in the worst case travel 300 feet.” Although most of the riparian slopes on the Clearwater National Forest are steep, infiltration capacities are very high. The Clearwater National Forest has found, through BMP audits that non-channelized sediment generally does not move beyond 25 to 30 feet within the riparian buffers.[3]

It is also obvious from the literature that riparian buffers are effective in preventing non-channelized sediment movement from the upland slope to the stream during prescribed burning. DeBano and others (1998) reported that, “When only the upland watershed is burned, the riparian ecosystem acts as a buffer between the burned hillslope and stream.

[3] Prior to the implementation of PACFISH/INFISH buffers, the Forest generally followed the Idaho FPA Rules on Class II streams. When the Class II buffer strip was five feet, these were generally not effective in preventing non-channelized sediment from entering the streams (this data is included in Table 1). Because of this, the buffer widths on the Clearwater National Forest) were increased to 25 feet (The FPA was later revised from five feet to 30 feet). BMP audits of these buffers generally showed that sediment did not move from the slope to the stream when a 25-30 buffer was applied.

However, when upland watersheds and riparian ecosystems are severely burned together, devastating effects can occur." These effects occur in severe wildfires and include sediment movement from the slope to the stream and resultant disruption of dynamic equilibrium. When riparian buffer strips are burned by wildfire, the filtering of sediment and nutrients from burned-over upland watersheds are lost, and as a consequence, these materials are likely to enter the stream (DeBano et al., 1998). However, these impacts can be mitigated when implementing a prescribed burn by recognizing the importance of buffer strips to the stream system and planning accordingly (Neary et al., 1993 and Lubke, 2000).[4] BMP audits on the Clearwater National Forest have indicated that current buffer strips used during prescribed fire are effective in preventing non-channelized sediment movement from the upland watershed to the stream (See Table 1).

The Forest now generally applies default INFISH (USDA Forest Service, 1995) and PACFISH (USDA Forest Service and USDI Bureau of Land Management, 1995) buffers, now 300 feet on perennial fish-bearing streams, 150 feet on perennial non-fish bearing streams, and 50-100 feet on intermittent streams, which are designed to *control non-channelized sediment below logging units*. They are also designed and implemented to meet the *Riparian Management Objectives* (RMO's) of maintaining pool frequency, water temperature, large woody debris, bank stability, lower bank angle, and width/depth ratio. BMP and PACFISH/INFISH audits have determined that these buffers are highly effective in controlling these factors. *Channelized* sediment from roads on the Clearwater National Forest is primarily controlled by avoidance. Lower and mid-slope road proposals are generally rejected or logging systems changed to allow only the construction of ridge-top or near ridge-top roads where there is no, or very little risk of producing channelized sediment. If, in the future, there is a decision to build a lower or mid-slope road, the Forest should consider all practices feasible, such as outsloping, to avoid channelized sediment delivery to streams.

Monitoring and Evaluation

This section describes the soil and sediment monitoring and evaluation that occurs on the Clearwater National Forest (USDA Forest Service, 2000).[5] The monitoring reflects both natural and anthropogenic surface erosion and mass wasting processes and resultant sediment delivery to streams and routing of that suspended and bedload sediment though the channel. Although extensive monitoring has occurred, it has not, nor is it necessary for monitoring to occur on each site-specific project (Federal Register, 2000).[6]

1. <u>Best Management Practices</u> implementation and effectiveness monitoring has been extensively discussed in this paper. This monitoring is occurring on a

[4] The fire manager considers several factors to obtain a low intensity prescribed fire, including presence of riparian areas, amount of fuel on the site, weather (temperature, relative humidity, wind, fuel moistures), and slope aspect and steepness (Lubke, 2000).
[5] A detailed monitoring description can be found in the Clearwater National Forest 2000 Watershed and Fisheries Monitoring Plan.
[6] The November 9, 2000 Federal Register, Page 67533. "It is important to clarify that monitoring in not required for all site-specific projects."

minimum of ten percent of all logging units and 100 percent of all roads. BMP audits generally occur after prescribed burning of timber harvest units has occurred.

2. INFISH/PACFISH implementation and effectiveness monitoring is occurring on all logging units and roads where BMP's are monitored. Monitoring has indicated that RHCA's are effective in meeting the RMO's and preventing sediment delivery to streams (Murphy, 2000).
3. Road Obliteration Monitoring is implementation and effectiveness monitoring that examines different treatments and determines suspended sediment and turbidity levels generated as a result of stream crossing removal and obliteration of roads constructed within RHCA's. Two sites are selected for monitoring each year.
4. Soil Compaction and Displacement Monitoring is implementation and effectiveness monitoring of management activities and wildfires on the physical properties of the soil resource.
5. Suspended Sediment Monitoring is effectiveness and validation monitoring performed at several locations to determine long-term trends in stream sediment levels and validate the Forest watershed model. Table 2 is a summary of streams where this monitoring occurs. An automatic sampler is installed in the stream and samples are collected each day between April and September.

Table 2: Suspended Sediment Monitoring Stations

Basin	Stream	Location	Record
Palouse River	Palouse River	Below Little Sand	1985-Current
Lochsa River	Pete King Creek	Mouth	1976-Current
Lochsa River	Canyon Creek	Mouth	1992-Current
Lochsa River	Deadman Creek	Mouth	1980-Current
Lochsa River	Fish Creek	Mouth	1992-Current
Lochsa River	Squaw Creek	Above Doe Creek	1997-Current
Lochsa River	Papoose Creek	Mouth	1996-Current
Clearwater River	Potlatch River	Below Little Boulder Creek	1995-Current
Clearwater River	Lolo Creek	Mouth	1991-Current
Clearwater River	Lolo Creek	Section 6 Bridge	1980-Current
Clearwater River	Eldorado Creek	Below Linda Creek	1991-Current
Upper North Fork of the Clearwater River	Quartz Creek	Mouth	1981-Current
Upper North Fork of the Clearwater River	Cold Springs Creek	Mouth	1999-Current
Lower North Fork of the Clearwater River	Elk Creek	Above Elk River	1981-Current

6. Bedload Sediment Monitoring is effectiveness and validation monitoring that occurs at the Elk Creek and Lolo Creek stations. Approximately 20 samples are collected at each station every year on the rising and falling limb of the annual hydrograph. The sampling is used to determine long-term trends in bedload sediment levels, calculate total sediment levels (with the suspended sediment), and validate the Forest watershed model.

7. Channel Morphology Monitoring, including Riffle Stability Index measurements (Kappesser, 1993), Wolman pebble counts (Wolman, 1954), and surveyed stream cross sections and gradients are done on approximately 10 to 20 stream channels each year. Monitoring is generally done in three representative riffles near the mouth of named streams.
8. Stream Substrate Monitoring including channel substrate coring to determine percent fine sediment by depth is done at Pete King Creek each year. Coring and cobble embeddedness samples are collected at 25 stations.
9. Fish Habitat and Population Surveys occur on a number of streams each year. It is the goal of the Forest to survey all streams at least once and streams where management activities are occurring every ten years. These surveys include measurements of stream bank stability, cobble embeddedness, riffle stability index, and channel stability evaluations.
10. Aquatic Flood Assessment Monitoring occurs each year on several streams that were the most impacted by the 1995-1996 Flood. One or more reaches of a stream are monitored every second or third year. Parameters are the same as in fish habitat and population surveys.

Summary and Conclusions

In conclusion, the three methods of controlling surface erosion discussed; avoidance, prevention, and erosion control, are highly effective in preventing new sediment delivery to streams and in reducing existing erosion sources. As watershed managers have employed the techniques described within this paper, surface erosional processes have lessened and watersheds and streams have improved. In 1992 the number of watershed meeting Forest Plan water quality standards was 37, or 29 percent of the watersheds where data was gathered (Jones and Espinosa, 1992). In 1997, when the second watershed condition report was completed, 121 watersheds were meeting Forest Plan standards, or 43.5 percent of the watersheds where data was collected (Jones and Murphy, 1997). Stream and watershed conditions should continue to improve on the Clearwater National Forest as NEPA analysis includes proven methods to control accelerated surface erosion, such as best management practices, INFISH and PACFISH RHCA's, and road obliteration and maintenance.

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